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Dr. Nathaniel White

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The Lowell Observatory
1400 W. Mars Hill Road
Flagstaff, AZ 86001

8. PERFORMING ORGANIZATION REPORT NUMBER
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13. ABSTRACT *(Maximum 200 words)*

This final technical report for contract N00014-91-C-2224 summarizes all work accomplished in the construction of the Navy Prototype Optical Interferometer (NPOI), Phase I. Reference is made to all environmental reports and permits, construction of roads, buildings, array piers, and power distribution. Quarterly reports, summary budget, job descriptions of personnel, and publications are included.

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FINAL REPORT

PHASE I CONSTRUCTION
of the
NAVY PROTOTYPE OPTICAL INTERFEROMETER

Contract N00014-91-C-2224

16 September to 12 April 1996

Nathaniel M. White
The Lowell Observatory
1400 Mars Hill Road
Flagstaff, AZ 86001

August 16, 1997

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Introduction to technical report

The Lowell Observatory was contracted by the Naval Research Laboratory to construct Phase I of the Navy Prototype Optical Interferometer and provide assistance in its implementation and operation. The site of construction is The Lowell Observatory special use-permit area on Anderson Mesa in the Coconino National Forest south east of Flagstaff, Arizona. (USDA Holder No. 2052-02)

The period of this contract was September 16, 1991 to April 15, 1996 including a seven month extension. This technical report provides summary information on all accomplishments under this contract. Copies of relevant memoranda, the Lowell proposal (just the summary), The USDA permit (only first two pages of the 9 page document is reproduced here), and the USFS Decision Notice to proceed are included in this report for completeness.

To meet all Contract N00014-91-C-2224 expectations the following deliverables were accomplished or provided:

1. Access to the Lowell Observatory observing site on Anderson Mesa in the Coconino National Forest by permit from the U.S. Department of Agriculture (USDA) - Forest Service (USFS).

2. Meet all National Environmental Protection Agency (NEPA) requirements which included public hearings, written public input, wildlife and vegetation surveys, and archeological surveys and mitigation procedures.

3. Surveying and topological mapping of the entire site.

4. Public Service power to the site.

5. Underground power and signal distribution system.

6. Paved main access road and engineered unpaved array access roads.

7. State approved cistern and septic system.

8. A 2027 sq ft control building.

9. A 5,566 sq ft optical laboratory.

10. Four 450 sq ft astrometric buildings.

11. Construction of 16 concrete imaging stations and 4 astrometric stations.

12. Approximately 2000 ft of 8 ft security fence.

13. Labor for installing instrumentation, nightly operation of

the instrument, and maintenance and repair.

Significant Documents

Four documents are included in part or in whole. The first is the summary of the proposal by the Lowell Observatory for the construction and support of the optical interferometer. It provides a list of Lowell's responsibilities.

The Memorandum of Understanding between Lowell, USNO, and NRL describes a mutually acceptable structure for operating the interferometer.

The Decision Notice is the official statement by the USFS that Lowell could proceed with the construction of the interferometer on U. S. National Forest Lands.

The Special-Use Permit (first two pages only included) describes the USFS conditions under which the construction and operation of the interferometer must abide.

Proposal
to
The Center for Advanced Space Sensing
Naval Research Laboratory

SUPPORT OF THE PROTOTYPE OPTICAL INTERFEROMETER

This proposal covers the four-year interval September 1, 1991 through August 31, 1995, and is submitted as a modification of the initial proposal responding to NRL BAA 14-90, which appeared in *Commerce Business Daily*, issue No. PSA-0159 of Friday, August 17, 1990.

Authorizing Institutional Official: Robert Millis
(Signature)

Name: Robert L. Millis
Title: Director
Address: Lowell Observatory
1400 West Mars Hill Road
Flagstaff, Arizona 86001
Telephone: 602-774-3358

Introduction

Lowell Observatory is a non-profit corporation which has operated astronomical research facilities in Flagstaff, Arizona, since 1894. Thirteen Ph.D. astronomers are included in our total staff of 40. We operate eight telescopes in the Flagstaff area, including four at a "dark-sky" site on Anderson Mesa approximately 15 miles southeast of the center of the city.

The Anderson Mesa facilities are located in a one-square-mile use area within the Coconino National Forest. Currently, we are negotiating a long-range management plan with the U. S. Forest Service which will govern the operation of astronomical facilities on the Mesa for the next few decades. This plan also provides for more appropriate boundaries of the use area and for construction of additional astronomical facilities within the area. Several new facilities are under consideration, including one or more large optical interferometers.

This proposal is in response to NRL BAA 14-90 and offers services essential to the design and implementation of the proposed NRL prototype optical interferometer, if that research instrument is to be operated within the Lowell Observatory use area on Anderson Mesa. The work proposed here will take place during a four-year period beginning September 1, 1991.

Conditions

The NRL will contribute annually, along with other institutions having facilities within Lowell Observatory's use area on Anderson Mesa, a *pro rata* share, to be agreed upon annually in advance, of the cost for shared Anderson Mesa infrastructure, services, and any user fees that may be imposed by the U. S. Forest Service or other governmental agencies.

The NRL will, should the research program on the prototype optical interferometer be terminated at any point for any reason, accept responsibility for removal of all research equipment and related components from Anderson Mesa.

Specific Effort Goals

Lowell Observatory proposes to undertake work on the interferometer project with the following specific effort goals:

1. Conduct negotiations with appropriate representatives of the U. S. Forest Service, Coconino County, and other governmental agencies aimed at securing all permits required for implementation of a prototype optical interferometer within the Lowell Observatory use area on Anderson Mesa. This effort will include preparation of all necessary applications, attendance of necessary hearings and other meetings, and hosting of required public informational meetings, etc.

2. Solicit, select, and monitor the work of qualified entities for the purpose of preparing an accurate boundary survey and topographic map of the Anderson Mesa use area. The results of this survey are essential to determining the best site for the interferometer array within the use area.

3. Solicit, select, and monitor the work of qualified entities for the purpose of preparing an accurate geologic survey of the Anderson Mesa use area. This survey will determine soil types and depths as a function of position in the use area—information essential to selecting the best location and orientation for the array.

4. Solicit, select, and monitor the work of qualified entities for the purpose of determining where the interferometric array can be best placed. This investigation is essential to achieve maximum scientific results, given the constraints imposed by the results of items 2 and 3, above, by the U. S. Forest Service and by technical and operational requirements specified by NRL.

5. Upon successful completion of items 1 through 4, plan and oversee the work of qualified entities for the purpose of planning the basic array layout.

6. Upon successful completion of items 1 through 5, plan and oversee the work of qualified entities for the purpose of installing the necessary research support facilities.

7. Lowell personnel as requested by NRL will provide consulting, planning, implementing, and overseeing aspects necessary for establishing a prototype research optical interferometer and its numerous subsystems on Anderson Mesa, as requested by NRL, relevant to the plan and implementation of interferometer subsystems and based on decades of experience in the provision and operation of research telescopes in the Flagstaff area.

8. After completion of the establishment phase of the program, the Lowell Observatory will provide operation of the prototype optical interferometer for research on both the astrometry and imaging of celestial objects.

DEPARTMENT OF THE NAVY
NAVAL RESEARCH LABORATORY
WASHINGTON, D.C. 20375

IN REPLY REFER TO:
4200-166:KJJ:lem
7 January 1992

Dr. Robert L. Millis
Director
Lowell Observatory
Mars Hill Road
1400 West
Flagstaff, Arizona 86001

Dear Dr. Millis:

The Naval Research Laboratory's (NRL) Center for Advanced Space Sensing (CASS) and the U.S. Naval Observatory (USNO) wish, in collaboration with Lowell Observatory (Lowell), to initiate the testing of the feasibility of optical/IR interferometry for astrometry and imaging. In order to accomplish this task a prototype optical interferometer will be fabricated and tested at Lowell Observatory. This interferometer will be known as the Navy Prototype Interferometer (NPI). As a component of this joint development, we propose the following principles as the basis for mutually beneficial working relationship:

1. Management of the NPI will be conducted under the direction of a Board of Directors (BOD) consisting of the Director of NRL's Center for Advanced Space Sensing, the Scientific Director of the USNO, the Director of Lowell Observatory, and any other members mutually agreed to by these three Directors. The BOD will meet at least once per year in Flagstaff with other meetings to be called by the Chairman as needed.
2. The Director of NRL's Center for Advanced Space Sensing and the Scientific Director of the USNO will alternately serve as Chairman of the BOD with the period of service for each of one U.S. Government Fiscal Year, currently 1 October to 30 September of each calendar year.
3. A tasking/maintenance group (TMG) to conduct the daily experiments with the NPI will be established at Lowell and operated under contract to the NRL and/or the USNO.
4. Each participating institution will maintain a scientific group independent of the TMG and regularly use the instrument for research. Upon request, Lowell astronomers will be allocated for their own research a minimum of 15% of the scheduled experiment time on each component of the NPI distributed equitably throughout the year.
5. Lowell will provide visiting NRL and USNO personnel and other approved users of the NPI access to Lowell Observatory lodging, computers, library, and instrument shops at the same cost as customarily charged to other visiting scientists.
6. In any publication or report concerning the NPI or work done with it, the telescope will be referred to as the Navy Prototype Interferometer at the Lowell Observatory.

If you agree with this proposal, please sign below and return two copies for our files.

With best regards,

Kenneth J. Johnston
Director
Center for
Advanced Space Sensing
Naval Research Laboratory

Gart Westerhout
Scientific Director
U.S. Naval Observatory

Robert L. Millis
Director
Lowell Observatory

FI20-2-2

DECISION NOTICE

and

FINDING OF NO SIGNIFICANT IMPACT

Lowell Observatory Long Term Management Plan for the Operation of Astronomical Facilities on Anderson Mesa

USDA Forest Service
Coconino National Forest
Mormon Lake Ranger District
Coconino County, Arizona

I. INTRODUCTION

Since 1961, Lowell Observatory has operated astronomical facilities on Anderson Mesa under Forest Service special use permits. This site is a unique and extremely important area for astronomical use near Flagstaff. Presently, there are four telescopes on this site which are used by Lowell astronomers, University faculty and students, and visiting scientists from the U.S. and foreign counties.

Lowell Observatory has proposed an update of its long term management plan for Anderson Mesa. Part of this proposal includes construction of a Navy Prototype Optical Interferometer within the existing permit area to provide advanced astronomical instrumentation and to produce previously unattainable scientific data to help further understand our solar system and the universe. An Environmental Assessment that documents the effects of Lowell's proposal and the alternatives to this proposal has been completed. The Environmental Assessment is available for review at the Mormon Lake Ranger District Office (4825 S. Lake Mary Road, Flagstaff) and the Coconino National Forest Supervisor's Office (2300 E. Greenlaw Lane, Flagstaff). This Decision Notice documents my decision on the long term management plan for the operation of astronomical facilities on Anderson Mesa.

II. PROPOSED ACTION

It is my decision to approve the Lowell Observatory proposal for updating its long term management plan (Alternative B in the Environmental Assessment). Actions included in this proposal are a decrease in the current special use permit area, the construction of a Navy Prototype Optical Interferometer in two phases, construction of an access road, construction of a control building, construction of a laboratory building, and bringing power and telephone utilities to the interferometer site. Some roads near the interferometer will be obliterated, and an alternate access route will be constructed near Vail Lake. Details of the propcsal can be found in the Environmental Assessment.

This decision is based on my desire to accommodate long term astronomical research activities on Anderson Mesa while being sensitive to the visual qualities of the mesa, the roads and trails use in the area, cultural resources, and special status wildlife species that may be in the area. The selected alternative has provisions to mitigate the visual impacts to the area by reducing the height of structures and using blending colors. Road access will be implemented with limited removal of trees and vegetation. Interpretive signs will provide the users with information on the facilities. In addition, unnecessary roads will be obliterated. There are several "special status species" of wildlife using Anderson Mesa, but the area of disturbance is too small (10 acres) to have any impacts on wildlife. The cultural resources located in the project area have been determined to be non-significant and in-eligible for inclusion to the National Register of Historic Places.

The only other alternative considered in this decision was the No Action alternative (Alternative A). This alternative was not chosen because it would not improve the astronomical presence at Flagstaff. Two other alternatives that were considered in the Environmental Assessment but not analyzed in detail were a change in the boundaries of the permit area and selection of a site other than Anderson Mesa for the interferometer. Only two other sites were available near Flagstaff: Mars Hill and the U.S. Naval Observatory. Ambient background light from the City of Flagstaff makes the Mars Hill location unacceptable. The westward expansion of Flagstaff threatens the type of research that can be done at the Naval Observatory site. If the Coconino National Forest cannot accommodate the facility, then sites in other counties, states, or countries will be considered.

III. SCOPING AND PUBLIC INVOLVEMENT

A scoping document describing Lowell's proposal and inviting comment on the proposal was sent to approximately 200 federal agencies, state agencies, groups, or individuals. On April 21, 1992, Lowell Observatory and the Mormon Lake Ranger District held a public meeting to discuss the proposal. In addition to these efforts, the Grand Canyon Trust, the Sierra Club, the Arizona Department of Environmental Quality, the Hitching Post Stables, and the Arizona Trails organization were telephoned to ask for their concerns. The Arizona Game and Fish Department made an on-site visit to the site. The Scoping Document for this project describes the public involvement efforts in detail.

IV. FINDING OF NO SIGNIFICANT IMPACT

I have determined that this action is not a major federal action and will not significantly affect the quality of the human environment, individually or cumulatively with other actions in the general area. Therefore, an environmental impact statement is not needed. This finding is based on the following factors:

There are no known effects to human health and safety, critical habitat for endangered, threatened, or sensitive species, or cultural and historic values.

The physical and biological effects are limited to the immediate geographic area.

The environmental effects on the quality of the human environment are not highly controversial from a scientific or technical standpoint.

The action, in conjunction with other existing and foreseeable actions on and adjacent to the analysis area, does not cause a cumulative effect which is significant.

The action does not threaten a violation of Federal, State, or local laws or requirements imposed for the protection of the environment.

V. FINDINGS REQUIRED BY OTHER LAWS

This action is consistent with the management direction for standards and guidelines in the Coconino National Forest Plan and with direction contained in the National Forest Management Act. From the results of the site specific analysis documented in the Environmental Assessment, I conclude that the project complies with the requirements of 36 CFR 219.27.

VI. IMPLEMENTATION AND APPEALS

This decision is subject to appeal in accordance with 36 CFR 217. A Notice of Appeal must be in writing and clearly state that it is a Notice of Appeal being filed pursuant to 36 CFR 217. Appeals must be filed consistent with 36 CFR 217.9 "Content of Notice of Appeal" and must be filed with: Larry Henson, Regional Forester, 517 Gold Avenue SW, Albuquerque, New Mexico, 87102, within 45 days from the date of publication of the legal notice of the decision in the Arizona Daily Sun. This project may not be implemented for seven days following the publication of the legal notice of the decision.

If you wish to discuss this decision, contact Sharon Metzler, District Ranger, Mormon Lake Ranger District at telephone (602) 556-7474.

for Fred Trevey
Forest Supervisor

Nancy J. Cotner

8/7/92
Date

FS-2700-4
(04/92)

U. S. DEPARTMENT OF AGRICULTURE Forest Service	Holder No. 2052-02	Issue Date 08/10/92	Expir. Date 12/31/12
	Type Site(s) 425	Authority 676	Auth. Type 20
SPECIAL-USE PERMIT Authority: Act of Oct. 21, 1976 FLPMA	Region/Forest/District 03/04/05		State/County 04/005
	Cong. Dist. 03	Latitude - - -	Longitude - - -

Lowell Observatory (Holder Name) of 1400 W. MARS HILL RD (Billing Address - 1)

(Billing Address - 2) FLAGSTAFF (City) ARIZONA (State) 86001 (Zip Code)

(hereinafter called the Holder) is hereby authorized to use or occupy National Forest System lands, to use subject to the conditions set out below, on the Mormon Lake Ranger District of the Coconino National Forest.

This permit covers 180 acres and is described as E/2 NE/4 SW/4, E/2 SE/4 SW/4, W3/4 NW/4 SE/4, and W/2 SE/4 SE/4, Section 22; and N/2 NW/4 NE/4, SE/4 NW/4 NE/4, and W/2 NE/4 NE/4, Section 27, T20N, R8E, G&SRBM as shown on the location map attached to and made a part of this permit, and is issued for the purpose of:

1) Construction of both Phase I and Phase II of an interferometer and related structures in accordance with the approved building plan and operating plan attached to and made a part of this permit.
2) Maintenance and operation of all existing (see Appendix A) and new facitlites in accordance with the attached operating plan attached to and made a part of this permit.

The above described or defined area shall be referred to herein as the "permit area". The attached "Lowell Observatory Anderson Mesa Facility Long-Range Management Plan" is also hereby made a part of this permit, and will be updated as necessary.

TERMS AND CONDITIONS

I. AUTHORITY AND GENERAL TERMS OF THE PERMIT

A. Authority. This permit is issued pursuant to the authorities enumerated at Title 36, Code of Federal Regulations, Section 251 Subpart B, as amended. This permit, and the activities or use authorized, shall be subject to the terms and conditions of the Secretary's regulations and any subsequent amendment to them.

B. Authorized Officer. The authorized officer is the Forest Supervisor or a delegated subordinate officer.

C. License. This permit is a license for the use of federally owned land and does not grant any permanent, possessory interest in real property, nor shall this permit constitute a contract for purposes of the Contract Disputes Act of 1978 (41 U.S.C. 611). Loss of the privileges granted by this permit by revocation, termination, or suspension is not compensable to the holder.

D. Amendment. This permit may be amended in whole or in part by the Forest Service when, at the discretion of the authorized officer, such action is deemed necessary or desirable to incorporate new terms, conditions, and stipulations as may be required by law, regulation, land management plans, or other management decisions.

E. Existing Rights. This permit is subject to all valid rights and claims of third parties. The United States is not liable to the holder for the exercise of any such right or claim.

F. Nonexclusive Use. Unless expressly provided in additional terms, this permit is not exclusive. The Forest Service reserves the right to use or allow others to use any part of the permit area for any purpose.

G. Forest Service Right of Entry and Inspection. The Forest Service shall have free and unrestricted access at all times, including the right to enter into all buildings, dwellings, and other facilities to ensure compliance with the terms and conditions of this permit. In addition, the Forest Service may enter the authorized facilities for any purpose or reason consistent with any right or obligation of the United States under any law or regulation.

H. Assignability. This permit is not assignable or transferable. If the holder through death, voluntary sale or transfer, enforcement of contract, foreclosure, or other valid legal proceeding shall cease to be the owner of the improvements, this permit shall terminate.

I. Permit Limitations. Nothing in this permit allows or implies permission to build or maintain any structure or facility, or to conduct any activity unless specifically provided for in this permit. Any use not specifically identified in this permit must be approved by the authorized officer in the form of a new permit or permit amendment.

II. TENURE AND ISSUANCE OF A NEW PERMIT

A. Expiration at the End of the Authorized Period. This permit will expire at midnight on December 31, 2012. Expiration shall occur by operation of law and shall not require notice, any decision document, or any environmental analysis or other documentation.

B. Construction. Any construction authorized by this permit may commence by August 21, 1992 and shall be completed by September 10, 1994. If construction is not completed within the prescribed time, this permit may be revoked or suspended.

C. Minimum Use or Occupancy of the Permit Area. Use or occupancy of the permit area shall be exercised at least 365 days each year, unless otherwise authorized in writing under additional terms of this permit.

Chronology

1990 - NRL/Lowell discussions on interests in collaboration.

December 12, 1990 - Proposal submitted to NRL.

January 7, 1991 - Memorandum of understanding signed.

September 16, 1991 - Contract accepted.

Fall 1991 - Aerial and ground survey of topography and locations.

Winter 1991/1992 - Site plan development.

February through August 1992 - USFS/NEPA/EIS process.

Summer 1992 - Geotechnical data gathered.

September 1992 - Construction begins.

Fall 1992 - Paved access road, cistern, power, and control building construction.

March through July 1993 - Septic system and laboratory constructed.

August - December 1993 - Inner Array excavation, footings, drilling, and pier construction.

December - January 1993/94 - Astrometric hut construction.

Winter - Spring 1994 - Assembly of inner array pipe system and completion of construction details.

May 17, 1994 - First light passes through instrument.

September 13, 1994 - First internal white light fringes recorded.

October 28, 1994 - First stellar fringes.

Fall - Spring 1994/95 - Instrument assembly, testing, and modifications.

Summer - Fall 1995 - Assembly, testing, observing, and archeological studies.

Winter - Spring 1995/96 Surveys, clearing and road base construction in preparation for construction of Phase II piers.

Reports and Maps

1. Surveying

Sub-contractor, WFM Engineers & Surveyors
a) Photogrametric aerial data
b) Boundary and orientation survey
c) Site plan survey
d) Site map, 1" to 100', 1 foot contour
e) Road cross section design and survey

Sub-contractor, Northland Exploration
a) On site surveying during construction

2. Geotechnical

Sub-contractor, Western Technologies
a) Soil testing for road cross section design
b) Core sampling for laboratory foundation and floors
c) Core sampling for inner array foundations
d) As built concrete strength test results

3. Environmental Reports

a) **LOWELL OBSERVATORY LONG-TERM MANAGEMENT PLAN FOR ANDERSON MESA -- ENVIRONMENTAL ASSESSMENT**, Northern Arizona University, May 24, 1990

b) **SCOPING DOCUMENT, LOWELL OBSERVATORY LONG TERM MANAGEMENT PLAN FOR THE OPERATION OF ASTRONOMICAL FACILITIES ON ANDERSON MESA COCONINO COUNTY, ARIZONA**, SWCA, Inc., June 11, 1992

c) **A SUMMARY OF CULTURAL RESOURCES PROJECTS WITHIN THE PROPOSED LOWELL OBSERVATORY ASTRONOMICAL SPECIAL-USE PERMIT AREA BOUNDARIES**, SWCA, Inc., May 26, 1992

d) **CULTURAL RESOURCES INVENTORY FOR THE PROPOSED LOCATION OF PHASE I CONSTRUCTION OF NAVY PROTOTYPE INTERFEROMETER, WITHIN THE LOWELL OBSERVATORY ASTRONOMICAL SPECIAL-USE PERMIT AREA ON ANDERSON MESA, COCONINO NATIONAL FOREST, ARIZONA**, SWCA, Inc., June 23, 1992

e) **FINAL ENVIRONMENTAL ASSESSMENT, LOWELL OBSERVATORY LONG TERM MANAGEMENT PLAN FOR THE OPERATION OF ASTRONOMICAL FACILITIES ON ANDERSON MESA COCONINO COUNTY,ARIZONA**, SWCA, Inc., July 31, 1992

f) **CULTURAL RESOURCES SURVEY AND REVIEW WITHIN THE LOWELL OBSERVATORY ANDERSON MESA PERMIT AREA, MORMON LAKE RANGER DISTRICT, COCONINO NATIONAL FOREST, ARIZONA**, Northland Research, Inc., April 16, 1993

g) **CULTURAL RESOURCES SURVEY AND REVIEW WITHIN THE LOWELL OBSERVATORY ANDERSON MESA PERMIT AREA, AND AN ASSESSMENT OF THE EFFECTS OF PHASE II NPOI CONSTRUCTION, MORMON LAKE RANGER DISTRICT, COCONINO NATIONAL FOREST, ARIZONA**, Northland Research, Inc., July 20, 1993

h) **DECISION NOTICE AND FINDING OF NO SIGNIFICANT IMPACT**, USDA Forest Service, Coconino National Forest, Mormon Lake Ranger District, Coconino County, Arizona, August 7, 1992

i) **OPERATIONS PLAN FOR CONSTRUCTION OF THE NPOI**, Lowell Observatory, August 24, 1992

4. Pier Structural Analysis

a)Mirth, R. and Loverich, E. 1993 **Study of Instrument Supports for the Lowell Observatory**, Project Report.

5. Quarterly Reports

These reports are included to provided a summary description of the project progress, accomplishments, and challenges for the contract period. They are attached as Appendix A.

Description of Deliverables

1. Environmental Requirements and Actions

a) In order to be permitted to construct NPOI on the Coconino National Forest the following actions had to be taken: public hearings, biological surveys, archeological surveys, visual impact studies, development of a master site plan, and complete any mitigations of concerns. The reports produced to address these requirements have been listed above.

b) Fencing, building and roof colors, and road placement were designed to meet USFS concerns for visual degradation of the natural surroundings and to avoid disruption of the natural habitat and water flows.

2. Structures

All structures were built to meet all local codes including handicap access.

a) 1600 ft of 8 ft high chain link security fence enclosed the phase I complex.

b) A 2027 sq ft control building contains a garage/shop, bathroom, kitchen, eating area, office space, and main control room for the interferometer. This building has separate power distribution for computers and it contains the main power distribution and telephone system for the site. Runoff water from the

metal roof is stored in a 10,000 gal cistern for the gray water system.

c) A 5566 sq ft optical laboratory building contains five specialized rooms, the mechanical room, the electronics hardware room, the light distribution room or manifold room, the fast delay line room, and the beam combining room. The latter three rooms have floors that are isolated from each other and the building to dampen vibrations. The walls and ceiling have R-48 insulation or more. The construction is the same as the control building with split face, brown masonry walls and brown metal roof. The electronics room is separately air conditioned from the rest of the building. For temperature stability, the air temperature in the various optically sensitive rooms is kept at the natural floor temperature. The floor is four feet below ground level.

d) A four to five foot deep trench was excavated to solid basalt over the entire inner array site. A layer of lean concrete from one to three feet thick provided the flat base for pier and astrometric hut footings. All footings were one foot thick and reinforced with steel. Four stem walls and 125 piers were build using 900 cubic yards of concrete.

e) Four metal buildings with slide off roofs were constructed to house the astrometric instruments. These have a partial basement and a temperature stable area insulated from the rest of the hut for the laser metrology system.

3. Roads and utilities

a) Approximately 1100 ft of paved access road designed for 80,000 GVW capacity provides connections between buildings and the main entrance road. About 500 ft of engineered gravel road provides access within the inner array.

b) A state approved mound septic system was constructed.

c) A 10,000 gallon gray water system supplied by roof runoff was installed to engineered standards.

d) An underground power distribution system provides 480 vac to the buildings and array where it is stepped down to 208 and 120 vac. Lightening protection is provide by a series of buried ground cable and lightening rods.

4. Plans

a) On file are plans for all structures, power distribution, roads, piers, and septic system. These are located at both the Lowell Observatory and on the NPOI site.

5. Major New Equipment

a) A 14 HP John Deere utility tractor was purchased for snow

removal, hauling, and grass and weed cutting.

b) A GMC 3500 series flat bed and crane truck was purchased for moving the siderostats on a regular basis as well as to help in deploying the many heavy parts of the vacuum system.

c) A metal sea going storage container was purchased for supplies.

Budget Summary

The following is the final accounting for this contract. It is in the form of the Lowell Observatory internal accounting ledger. The sub-categories are self explanatory. Under the balance column are the total expenditures.

*Acct Day	Description	Ref	Activity	Balance
*7500	NRL N00014-91C-2224 RLM 64.7% 2,878,359.00 4/12/96			1,543.07CR
	Total Reimbursements		521.00CR	
	Total Disbursements		8,253.86	
			7,732.86	6,189.79
*-10	OTHER			3,087.69
			0.00	3,087.69
*-11	OFFICE SUPPLIES			1,100.51
			0.00	1,100.51
*-12	ELECTRONICS LAB SUPPLIES			1,456.21
			0.00	1,456.21
*-13	MACHINE SHOP SUPPLIES			182.77
			0.00	182.77
*-14	MISCELLANEOUS SUPPLIES			12,179.70
			0.00	12,179.70
*-15	REFERENCE MATERIALS			1,680.20
			0.00	1,680.20
*-16	COMPUTER SUPPLIES			2,311.31
			0.00	2,311.31
*-21	Photographic Expenses			1,185.41
			0.00	1,185.41
*-31	NEW EQUIPMENT			141,771.17
			0.00	141,771.17
*-32	PARTS AND REPLACEMENTS			4,686.74
			0.00	4,686.74
*-35	SPECIAL PURCHASES AND SERVICES			15,240.41
			0.00	15,240.41
*-41	DOMESTIC TRAVEL			14,490.17
			0.00	14,490.17
*-42	FOREIGN TRAVEL			2,358.00
			0.00	2,358.00
*-43	EMPLOYEE RELOCATION EXPENSES			372.43
			0.00	372.43
*-51	SUB-CONTRACTS			1,029.47
			0.00	1,029.47
*-52	CONSULTANTS			4,635.47
			0.00	4,635.47

*Acct Day	Description	Ref	Activity	Balance
*-53	SERVICES			11,957.16
			0.00	11,957.16
*-57	ARCHITECT./ENG./SURV./STAK.			123,860.50
			0.00	123,860.50
*-58	GEO-TECHNICAL/TESTING			9,606.40
			0.00	9,606.40
*-59	ARCHEOLOGY/ENVIRONMENTAL			28,348.48
			0.00	28,348.48
*-61	PUBLICATIONS			160.00
			0.00	160.00
*-63	TELEPHONE			19,654.49
			0.00	19,654.49
*-64	POSTAGE			164.61
			0.00	164.61
*-65	SHIPMENTS			1,120.76
			0.00	1,120.76
*-66	ELECTRIC POWER/HEATING FUEL			37,321.01
			0.00	37,321.01
*-75	Truck/Auto Expenses			230.00
			0.00	230.00
*-76	TEMPORARY/FACILITIES			1,942.43
			0.00	1,942.43
*-77	ROADWAYS/UTILITIES			228,841.39
			0.00	228,841.39
*-78	LANDSCAPE/RESTORATION			17,118.12
			0.00	17,118.12
*-79	FENCING			42,781.03
			0.00	42,781.03
*-86	CONTROL BUILDING			171,835.56
			0.00	171,835.56
*-87	LAB BUILDING			449,381.09
			0.00	449,381.09
*-88	SIDEROSTAT/PIERS/ENCLOSURES			726,687.93
			0.00	726,687.93
*-89	PROJECT CONTINGENCY			16,784.27
			0.00	16,784.27

*Acct Day	Description	Ref	Activity	Balance
*-90	GROSS SALARIES			428,359.70
			0.00	428,359.70
*-91	EMPLOYER FICA			32,397.37
			0.00	32,397.37
*-93	TIAA RETIREMENT			14,690.39
			0.00	14,690.39
*-94	MEDICAL INSURANCE			21,528.64
			0.00	21,528.64
*-95	TIAA DISABILITY INSURANCE			1,090.66
			0.00	1,090.66
*-96	TIAA LIFE INSURANCE			928.19
			0.00	928.19
*-97	INDUSTRIAL INSURANCE			5,094.85
	State Fund Div.1/1/95-13/31/95	5970	521.00CR	
			521.00CR	4,573.85
*-99	OVERHEAD			277,163.24
	1994 o/h rate adjustment	1300	430.20	
	1995 o/h rate adjustment	1300	7,823.66	
			8,253.86	285,417.10

Comments on Collaboration and Progress

1. Interaction with the USFS was cordial based on more than thirty years of astronomical presence on Anderson Mesa in the Coconino National Forest. We worked very hard to meet all requirements although the outcome was always unpredictable and sometimes required long waiting periods most likely because of under staffing.

2. Lack of cash flow caused some worry as the Observatory, with limited private funds, carried the project over many months. During 1994 construction came to a near halt because of budget cut backs. The project progress was slowed for that period of time.

3. Collaboration with Navy scientists and engineers has been efficient and cordial.

Personnel

A total of four employees worked directly under this contract and on average made up half of the technical on site work force. Their job titles were site/development manager, electronics technician, observer/technician I, and observer/technician II. These employees were continuously involved in essential work at all levels of installing instrumentation, aligning, testing, assembling, maintaining, and operating the interferometer.

Two employees of Loven Contracting, Flagstaff, AZ, were hired during actual construction to provide professional oversight expertise at the site and in preparing and reviewing all designs, bid specification, and performance standards.

Publications

Only publications directly funded under this contract are included. Numerous other publications relative to this project can be found on the NPOI home page through www@lowell.edu or through the USNO.

White N.M. and Mozurkewich D., 1996 *NPOI: Applications and Limitations to Solar System Observations*, ASP Conference Series, Vol 107, Rettig and Hahn, eds, p123.

White N.M., 1994 *The construction of the Navy Prototype Optical Interferometer at the Lowell Observatory, a Video Display*, Bull. Am. Ast. Soc., Vol 26, #4.

White, N.M., Millis, R.L., Franz, O.G., Loven, J.M., Hutter, D.J., Johnston, K.J., Armstrong, J.T., and Mozurkewich, D. 1994 *Progress Report on the Construction of the Navy Prototype Optical Interferometer at the Lowell Observatory*, In Proceedings SPIE, Vol 2200, J.B. Breckinridge, Ed., p242.

APPENDIX A

Quarterly Reports for Contract NOOO14-91-C-224

Covering the Period

September 16, 1991 through April 12, 1996

QUARTERLY PROGRESS REPORT
January–April 1996

Contract N00014-91-C-2224
Contractor: Lowell Observatory

Summary: This is the last quarterly report for this contract. Lowell personnel were critically involved in all aspects of the implementation and testing of the instrument, infrastructure development, and maintenance and operations. Permission to proceed with Phase II construction has been formally received, and Phase II construction has begun.

Accomplishments

(1) Bids were received for the siderostat room refrigeration; but, because of budget cuts, this has been delayed.

(2) Formal clearance and permission to proceed has been granted in letter form by the USFS.

(3) Site surveying for Phase II has been completed.

(4) Bids for site clearing, road preparation, pier and bolt placement surveying, and concrete pier installation have been received and subcontractors have been selected and approved.

(5) Road preparation for Phase II access is 50% completed.

(6) The heating and air-conditioning system of the optical laboratory was modified to better handle the heating load of the electronics room.

(7) Lowell employees continued to assist in all aspects of the design, commissioning, testing, operation, and maintenance of the interferometer. In one specific case, Lowell personnel assembled, vacuum tested, and lowered the 25 metrology tanks into their predrilled wells. This was about a three-man-month effort.

(8) A proposal by the Lowell Observatory in response to an NRL solicitation for Phase II deployment and site management was submitted and accepted. The start date for the new contract, N00014-96-C-2028, is April 15, 1996.

Problems or Delays

Rebidding, rescheduling of contractors, and reduction of the planned scope of work has been necessitated in response to proposed and real budget cuts. We have accomplished this with some loss of time and an overall projected increased cost for the completed project. The increased cost is incurred by dividing the project into segments that meet the proposed reduced funding. To complete the project, work is then stretched over a longer period of time with extra bidding, extra mobilization costs, a loss of economy of scale, and less efficient work scheduling and deployment of instrumentation.

Currently, an injunction on commercial cutting of ponderosa pine has inadvertently inconvenienced the work on Phase II. Some ten pine trees have to be avoided until the injunction is lifted, which is expected to occur in May. Work is continuing around the trees.

Planned Activities for Next Quarter on the New Contract

(1) Complete Phase II construction as funding will allow. This will include road preparation and as much of the concrete work as can be afforded.

(2) Assist in all aspects of the design, commissioning, testing, operation, and maintenance of the interferometer.

(3) We anticipate a significant amount of time will be devoted to the start-up and routine operation of the interferometer during the next quarter.

(4) Complete final technical report for this contract.

Nathaniel M. White
Project Manager

16 April 1996

QUARTERLY PROGRESS REPORT
September–December 1995

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Lowell personnel were critically involved in all aspects of the implementation and testing of the instrument, infrastructure development, and maintenance and operations. Important clearances have been given by the USFS regarding Phase II NEPA and archaeological requirements.

ACCOMPLISHMENTS

(1) Personnel under this contract continue to assist in designing, assembling, and testing components of the instrument. Areas of work included electronic subsections, hardware assembling, vacuum testing, insulating structures, exercising parts of the instrument, and general maintenance and improvements to the physical plant as well as nighttime testing of the interferometer.

(2) All on-site archaeological work has been completed and accepted by the USFS. The state agency SHPO is reviewing the findings.

(3) We have received verbal permission from the USFS to begin Phase II deployment in Spring 1996, pending the expected SHPO acceptance of the archaeological report. The USFS has provided written confirmation that the NEPA work recently performed is adequate for Phase II construction.

(4) A visual mitigation plan has been developed by a landscape architect and has been accepted by the USFS.

(5) Phase II site plans have been completed and are ready for RFP submittals.

(6) The modified HACV system for the lab building electronics room has been completed and is functioning.

(7) A design and RFP has been prepared for the refrigeration of the siderostat rooms.

(over)

ACCOMPLISHMENTS (continued)

(8) A major accomplishment was the assembly and installation of the 25 metrology tanks in the drilled wells within each astrometric hut.

PROBLEMS OR DELAYS

There were no major problems or delays during this quarter. This contract is being increasingly called upon to purchase parts and supplies as an efficient and necessary way to reduce delays in the testing and assembly of the interferometer.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Receive bids and begin installation of siderostat room refrigeration.

(2) Finish any remaining archaeologial and USFS requirements.

(3) Survey the Phase II site in preparation for development.

(4) Submit proposal in response to NRL solicitation for Phase II deployment and site management.

(5) Assist in all aspects of the design, commissioning, testing, operation, and maintenance of the interferometer.

Nathaniel M. White

Nathaniel M. White
Project Manager

6 February 1996

QUARTERLY PROGRESS REPORT
JULY–SEPTEMBER 1995

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Lowell personnel were critically involved in all aspects of the implementation and testing of the instrument, infrastructure development, and maintenance and operations. Essentially all originally planned construction of Phase I infrastructure has been completed. Elements of Phase II planning have begun.

ACCOMPLISHMENTS

(1) Personnel under this contract continue to assist in designing, assembling, and testing components of the instrument. Areas of work included electronic subsections, hardware assembling, vacuum testing, insulating structures, exercising parts of the instrument, and general maintenance and improvements to the physical plant as well as nighttime testing of the interferometer.

(2) An elastromeric coating has been applied to the astrometric hut roofs and will reduce the solar heat loading and seal remaining seams against leakage.

(3) All imaging piers and basements of the huts were insulated with a two-component spray on urethane insulation.

(4) The interiors of the huts in the observing areas have been insulated with carefully fitted CeloTex rigid insulation.

(5) The road crossing abutments, spans, and piers for the station-to-station metrology were completed. This was a significant construction job.

(6) A surface drainage system of grading and trenching was installed.

(7) Lightning arrestor poles and grounding were installed to protect the inner array.

(8) The crane truck was delivered.

(over)

ACCOMPLISHMENTS (continued)

(9) Bids were received and accepted for the archeological clearance study. Phase I, findings, has been completed. A limited Phase II analysis will be required.

(10) Dialog continued with the USFS concerning Phase II construction as well as Phase II construction site plan review.

PROBLEMS OR DELAYS

There were no major problems or delays during this quarter.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Assist in all aspects of the commissioning, testing, operation, and maintenance of the interferometer.

(2) Complete Phase II archaeological clearances.

(3) Receive acknowledgement from the USFS of acceptance of Phase I construction and approval for construction of Phase II.

(4) Finalize Phase II site plans.

(5) Modify HAVC for the lab building electronics room.

(6) Design and obtain bids for a heat removal system for the huts and inner array.

Nathaniel M. White

Nathaniel M. White
Project Manager

3 November 1995

QUARTERLY PROGRESS REPORT
MARCH-JUNE 1995

CONTRACT N00014-91-C-224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Instrumentation repair, trouble shooting, assembly, and testing continued during this quarter. Inner array access roads were completed. Designs and bids for further major purchases and construction were completed. The steps before Phase II construction required by the USFS have been clarified and have begun to be implemented.

ACCOMPLISHMENTS

(1) Three man months were devoted to electronic trouble shooting, modification of existing hardware, and designing and building various motor control units and other necessary gadgets for efficient use of the interferometer.

(2) A major portion of three man months was devoted to using and testing various parts of the interferometer during night time shake down operations.

(3) All metal work on the roof repairs has been completed. The roofs are water tight. Roof coating materials to provide a cooler roof surface and added protection have been selected and delivered.

(4) The inner array access roads have been satisfactorily completed.

(5) Pier to pier metrology pipe supports and road crossings have been designed and bids have been received and selected.

(6) The crane truck and conversion bids were awarded and are on order.

(7) The USFS requirements have been described with steps being taken to mitigate two archeological scatter sites along the southwest arm of Phase II. A full, new NEPA document will apparently not be necessary. Several co-op agreements were defined to help control pedestrian and vehicular traffic flow and visual impact mitigation.

(8) In cooperation with the USFS, a turn-around was constructed near the entrance to the interferometer site to help direct unnecessary traffic away from the interferometer.

(9) Development of Phase II construction plans continued.

(10) Lightening arrestor poles were installed with further grounding to be implemented.

(11) General assistance continued in all aspects of the implementation, maintenance, and operation of the interferometer.

PROBLEMS OR DELAYS

The only major delay was in defining the USFS requirements for Phase II construction. Funding for the next quarter will be exhausted by midterm without further transfers.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Assist in all aspects of the commissioning, testing, operation, and maintenance of the interferometer.

(2) Coat the hut roofs with elastometric covering.

(3) Insulate huts.

(4) Insulate piers.

(5) Construct metrology piers and road crossings.

(6) Complete lightening arrestor grounding.

(7) Receive crane truck delivery.

(8) Complete archeological clearances.

(9) Develop bids for Phase II construction (a portion or complete project). Work would begin subject to funding and length of construction season remaining after USFS requirements are met.

(10) Continue to work with the USFS to define and meet all requirements in a timely fashion.

Nathaniel M. White

Nathaniel M. White
Project Manager

5 July, 1995

sas:white:progress

QUARTERLY PROGRESS REPORT
JANUARY–MARCH 1995

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Improving and stabilizing the APD circuits, vacuum testing, and general assistance in the installation and testing of instrumentation were the primary efforts during this winter quarter. Progress was made in resolving roof leaks, establishing a process for USFS approval of Phase II start, and preparing for the construction season.

ACCOMPLISHMENTS

(1) Approximately three man months were devoted to improving the APD circuits to the point of attaining acceptable operating characteristics. The number of circuits, more than 100, made this effort time consuming.

(2) Several contractors assessed various ways of insulating the huts and imaging piers. Contractors were also consulted for ways to waterproof the hut roofs. The final solutions require dry, warm weather.

(3) A hut basement automatic water removal system was designed and implemented.

(4) Grading of the inner array was completed with the goal of draining water away from critical areas.

(5) Lowell personnel have contributed directly in vacuum testing, APD electronics debugging and tuning, and numerous other tasks essential in the commissioning of the interferometer. They have also been responsible for the overall maintenance of the infrastructure.

(6) After a series of meetings, site visits, and letters of understanding, a three point plan for visual impact mitigation has been accepted by the USFS Mormon Lake District.

(7) A bid for the crane truck was selected and final approval to purchase is pending.

PROBLEMS OR DELAYS

The only delays have been weather related. Thus road construction and roof repairs were not completed during the quarter.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Complete hut roof repairs.

(2) Complete inner array access roads.

(3) Complete pier to pier metrology pipe supports and road crossings.

(4) Insulate piers and huts.

(5) Award bids for crane truck and crane conversion.

(6) Implement USFS steps for Phase II construction. These include review of original environmental documents, complete visual impact mitigation plans, present completed plans for Phase II construction and impact mitigation plans.

(7) Begin preparation of Phase II design plans for bidding.

(8) Assist in all aspects in the commissioning of the interferometer, including anticipated night operations.

Nathaniel M. White
Project Manager

24 April 1995

QUARTERLY PROGRESS REPORT
OCTOBER–DECEMBER 1994

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Instrumentation assembly and testing, hut roof repair, and construction of the inner array access road occupied this quarter. Funding became available early in the quarter enabling construction starts.

ACCOMPLISHMENTS

(1) Preparation for the dedication of the NPOI entailed significant clean up and organizational activities that have benefited the project in general.

(2) A 10-micron thermal video was made of the piers and the center hut exterior and interior which has provided basic data for designing seeing improvement measures.

(3) The east hut roof has been repaired by completely replacing it using both in-house labor and contractors.

(4) The array access roads were designed, surveyed, and contract awarded. Do to winter weather construction was stopped after the road base was installed. It will be completed with warmer, dryer conditions.

(5) Lowell personnel have contributed directly in vacuum testing, metrology system assembly, APD electronics debugging and tuning, and numerous other tasks essential in the commissioning of the interferometer.

PROBLEMS OR DELAYS

With funding becoming available early in this quarter, projects delayed through the summer for lack of funds were begun. Winter weather has temporarily curtailed much of this work but will begin as weather permits.

The USFS is concerned about the visual impact of the interferometer. Discussions in December were thought to have resulted in a mutually acceptable plan of mitigation. Recently we have learned this not to be case. This should not delay current activities but could delay the start of phase II construction.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Develop and begin to implement a visual impact mitigation plan compatible with the scientific requirements of the project and acceptable to the USFS.

(2) Complete hut roof repairs, weather permitting.

(3) Complete array access roads, weather permitting.

(4) Insulate piers and hut interiors as part of the seeing improvements, weather permitting.

(5) Award bid for crane truck to move siderostats.

(6) Begin the discussion with the USFS to develop a mutually acceptable plane for commencing the construction of phase II. This process may require archaeological assessments and a public notice period.

(7) Assist in all aspects in the commissioning of the interferometer.

Nathaniel M. White
Project Manager

2 February 1995

QUARTERLY PROGRESS REPORT
JULY–SEPTEMBER 1994

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: In-house construction activities, instrumentation assembly and testing, and general organization and clean up have been the primary emphases of this quarter. Every effort has been made to facilitate the attainment of first light, although below-budget funding has continued to delay completion of the phase I construction.

ACCOMPLISHMENTS

(1) The construction of the four insulated astrometric metrology rooms occupied a major part of this quarter's effort. Three have been completed and the fourth is 90% finished.

(2) A surplus lathe was repaired and brought back to a fully functional machine by our technician, Karl Isbrecht.

(3) An observer, David Black, was hired and began work on August 29. His current duties are to assist in the completion of Phase I, equipment installation and maintenance, and to become familiar with the operation of the instrument.

(4) The assembly of the astrometric metrology systems has begun in the west, center, and east astrometric stations.

(5) Preliminary grading of the site was accomplished with in-house labor and rental equipment.

(6) A concept design for the array access road and specifications with estimated costs for the siderostat moving equipment were developed.

(7) General assistance in the instrument implementation.

PROBLEMS OR DELAYS

Only limited progress has been made in completing phase I of the construction because of an under-funded budget. All projects that required contract work planned for the summer season were not initiated due to lack of funds. This included roof repairs, road design and construction, and several concrete projects. Other work that might have better been accomplished with contractors was accomplished by our personnel, who would have been more beneficially used in working with the instrumentation installation and testing. The net result is a delay in the schedule of completion.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Complete astrometric hut construction.

(2) Complete hut seeing measurements and begin to make indicated improvements.

(3) Repair astrometric roof leaks.

(4) Design and build array access roads, weather and funding permitting.

(5) Dedication of the NPOI.

(6) Assist in the assembly of the astrometric metrology system.

(7) General assistance in the commissioning of the interferometer.

Nathaniel M. White
Project Manager

2 November 1994

QUARTERLY PROGRESS REPORT
APRIL–JUNE 1994

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: After a hiatus during the previous quarter because of zero cash flow, new contracts and commitments were made this quarter. A technician and observer were hired, and most of the planned activities were accomplished. The list of next quarter activities is conservative with the prospect of under-budget funding.

ACCOMPLISHMENTS

(1) A technical assistant was hired and began work May 23. From forty eight mostly qualified applicants, an observer was hired to begin work August 22.

(2) Astrometric station floors were constructed providing required access to the siderostat, beam compressor, and elevator piers and instruments.

(3) The stem walls and pads were cleaned, sealed, and additional concrete poured to stop ground water leakeage in the astrometric hut basements. There has not been sufficient rainfall to sufficiently test the repairs.

(4) All hut roofs have been fully motorized and limit protected.

(5) Preliminary grading around the array has been completed, and the area peripheral to the site has been policed as per Forest Service requirements.

(6) Employees under this contract continue to facilitate the implementation of the instrument as much as funds and time allow.

(7) After many discussions, meetings, letters, and site inspections, the subcontractor who erected the huts has accepted partial responsibility for the roof leaks. A procedure has been agreed upon to correct the problems.

PROBLEMS OR DELAYS

Timely reimbursements began during this quarter after a delay of a full quarter. Available funds were sufficient to accomplish some contract work but not sufficient to begin design and construction of the array access road and astrometric metrology pipe ways as planned and budgeted.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Facilitate instrument implementation with in house labor and as funding allows.

(2) Begin regular observations.

(3) Repair astrometric roof leaks.

(4) Funding and weather permitting, design access road and astrometric metrology pipe ways between stations.

Nathaniel M. White
Project Manager

20 July 1994

QUARTERLY PROGRESS REPORT
JANUARY–MARCH 1994

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Activities begun during the previous quarter were substantially completed during this quarter. Installation of power wiring to the array and the astrometric huts was completed in January. No additional commitments or contracts were made during this quarter because of lack of funding.

ACCOMPLISHMENTS

(1) All power and signal cabling has been installed throughout the array as designed. The astrometric huts contain single- and three-phase power, which is now available for installation of the siderostats and other equipment.

(2) Astrometric station huts were completed, although they have not been accepted because of roof leak problems. Consultation with the manufacturer and erector is in progress.

(3) The position of technical assistant was advertised and applications received. This position is part of the operations group described in the Memorandum of Understanding between Lowell, USNO, and NRL.

PROBLEMS OR DELAYS

Progress on this contract has been delayed because of a lack of cash flow. Contract extension was not received until five weeks into the quarter. No reimbursements were made during this quarter.

As a non-profit organization, Lowell Observatory is particularly not in a position to carry a large debt and therefore had to restrict costs to monthly bills and salary commitments. Planned activities for this quarter that have been delayed are the hiring of a technical assistant and observer, design and construction of astrometric station floors, design of the array access road to the array, and costs and services involved with installation of the interferometer were minimized.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Hire at least one observer and a technical assistant in anticipation of first tests of the interferometer.

(2) Resolve astrometric roof leak problems and basement leaks.

(3) Complete construction of astrometric station floors.

(4) Facilitate installation of the interferometer.

(5) Design access road and astrometric metrology pipe ways between stations.

(6) Complete spring grading and site clean up to Forest Service requirements.

(7) Motorize astrometric hut roofs.

Nathaniel M. White

Nathaniel M. White
Project Manager

11 April 1994

QUARTERLY PROGRESS REPORT
OCTOBER–DECEMBER 1993

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: All planned activities for this quarter were substantially completed. The concrete array structures, with backfilling and grading, were completed before harsh winter weather occurred. Underground power and signal conduits were installed. Astrometric station huts are about 60% complete and will be ready to receive the siderostats by the end of January.

ACCOMPLISHMENTS

(1) Fall construction can be severely limited by northern Arizona weather at 7200-ft elevation. However, good luck prevailed; through the diligent effort of the subcontractor, some 160 concrete piers were completed on schedule and met all engineering and design specifications. The critical placement of the piers and their mounting bolt patterns were monitored by a surveying team throughout the construction.

(2) Laying of power and signal conduits through the array required careful coordination between the intricate pier construction and backfilling. This was accomplished successfully.

(3) Backfilling of the array excavation and initial grading were finished before a major winter storm. The site is stabilized until spring weather allows for its completion.

(4) Metal buildings with an integrated roll-off roof to house the astrometric stations were delivered as scheduled in early December. Erecting the huts has proceeded more slowly than planned, due to weather. This has not delayed other activities, and the huts are expected to be completed before the siderostats are ready for installation in late January.

PROBLEMS OR DELAYS

There have been some weather-related delays that have not affected the overall work plan. Contract extension has not been received as of the submission of this report. This has delayed initiation of work for the January–March 1994 quarter.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Hire a technical assistant and possibly an observer as part of the operation management group described in the Memorandum of Understanding between Lowell, USNO, and NRL.

(2) Install all power wiring to the array.

(3) Complete astrometric station huts and make electrical connections to motorized covers.

(4) Design and construct inner platform for astrometric stations.

(5) Facilitate installation of the interferometer.

(6) Weather permitting, complete grading to Forest Service requirements.

(7) Design access road to the array.

Nathaniel M. White
Project Manager

27 January 1994

QUARTERLY PROGRESS REPORT
JULY–SEPTEMBER 1993

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: All planned activities for this quarter have been completed satisfactorily and as scheduled. Security fencing and restoration of disturbed areas have been completed and meet USFS expectations. The lab building is completed and scientific equipment is being installed. Optical anchor holes have been drilled and the array piers are under construction.

ACCOMPLISHMENTS

(1) The interferometer compound has been enclosed with a 10-foot-high chain-link fence. Disturbed areas have been rough graded and seeded per USFS specifications. Paved roads were chip sealed to reduce long-term maintenance costs. All roads are lined with posts and reflectors. The USFS and the Lowell contract shared costs for installation of a pole fence to discourage off-road vehicular traffic exiting the entrance road.

(2) The lab building is complete. Scientific equipment is being installed. The lab building appears to be meeting all anticipated needs. USNO and NRL personnel have installed the FDL support frames, optical tables, and manifold support. Please see *OIP Review*, September 15, 1993, by Dr. Hutter.

(3) Detail design of the array and astrometric huts was completed and bids selected. Both are under construction.

(4) The array foundation was excavated and the sub-foundation poured. The array pier footings will be constructed on top of the monolithic concrete mat.

(5) Twenty-five 10-inch-diameter, 20-foot-deep holes for the optical anchors were drilled into the concrete mat and solid basalt. This was a unique job vulnerable to many potential problems. Concrete Coring, Inc. completed the job with minimal delay and met all specifications. NRL and USNO personnel have placed inserts in to the holes and sealed them.

(over)

PROBLEMS OR DELAYS

There have been no delays during this quarter.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) All concrete installations related to the array will be completed.

(2) All power and signal conduits to the array will be installed and tested.

(3) The astrometric station huts will be installed and tested.

(4) Backfill and grading will be completed around the array.

(5) The site will be ready to install the siderostats.

Nathaniel M. White
Project Manager

27 September 1993

QUARTERLY PROGRESS REPORT
APRIL–JUNE 1993

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Rapid progress in constructing the optical laboratory highlights this quarterly report. The building is 80% complete, including interior painting, sidewalks, parking, and loading pads. Water and septic systems are now fully functional. The control building is linked to the pre-existing on-site facilities by fiber optic cable. Additional archeological surveys were performed satisfying USFS requirements. The array design is nearing completion.

ACCOMPLISHMENTS

(1) The lab building is nearly complete. Heat and electricity are currently being installed. Excavation into the basalt allowed building elevation to meet the optimal design requirements. Concrete strength tests exceeded by 50% the design criteria. The masonry 5500-square-foot building will be finished within the estimated 70 calendar days construction time.

(2) Connecting sidewalks, parking areas, driveways, and loading pads have been installed.

(3) Water and septic sytems have been completed and met local regulations. The control building lacks only the final rug and tile installation, which is to to be completed after the building is no longer needed as an on-site construction office.

(4) A final portion of the archeological survey was completed to USFS satisfaction. A pole fence along the access road was installed by the USFS in cooperation with the project. Some previously excavated boulders were removed from the site by USFS request.

(5) The array design is nearly finished. The design will meet the mechanical and thermal requirements based on a finite element analysis of the pier design. The electrical distribution system design is completed.

(6) Excavation of the array site has begun. The first phase of excavation will determine whether blasting and rock removal will be necessary to reach optimal design depth just as was necessary for the lab building.

PROBLEMS OR DELAYS

There have been no delays during this quarter.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Security fencing around the perimeter of the site will be installed.

(2) A third of the next quarter will be devoted to drilling the 25 optical anchor holes into the basalt for the astrometric piers.

(3) Construction of the piers should begin during the next quarter.

(4) The lab building will be completed and installation of scientific equipment will begin.

(5) Restoration of the disturbed areas to natural conditions will be started as required by the USFS.

Nathaniel M. White
Project Manager

1 July 1993

QUARTERLY PROGRESS REPORT
JANUARY–MARCH 1993

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: Significant progress occurred, despite extraordinary snow and rainfall during January and February. Full power and telephone service were brought to the remote site and terminated at the control building. The control building was completed and is being temporarily used as the site construction office. The optical laboratory building construction plans were completed and reviewed. The lab site has been excavated and the concrete work initiated.

ACCOMPLISHMENTS

(1) Three-phase power has been installed to the site via overhead lines and underground conduits. The main distribution panel for the entire site has been energized.

(2) Telephone service has been brought to the site, and the main distribution panel installed.

(3) The control building is completed, except for hooking up the cistern and septic system and final interior furnishing. The building has power, heat, and telephone and is serving as the project's on-site construction office.

(4) Construction plans for the lab building are complete and thoroughly reviewed by all NRL, USNO, and Lowell representatives. Particular attention has been paid to the isolated floor design and thermal stability of the building.

(5) The lab site excavation is completed. To reach the design depth of 5 feet below grade, blasting was required. No significant amount of water entered the excavation.

(6) The concrete work was separately bid and let. Footings are in place and construction continues.

(7) Requests for Bid have been sent out for construction of the remainder of the control building.

(8) Design of the inner array of piers is progressing through analysis of conceptual design. Several on-site meetings between Lowell, NRL, and USNO representatives were held to develop an integrated design that addresses the requirements of collocating the astrometric and imaging arrays.

PROBLEMS OR DELAYS

(1) Rainfall during January and February averaged more than four times normal. This caused some delay in begnning the lab site excavation.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Hook up control building water and septic system.

(2) Finish lab building concrete work and begin construction of the exterior.

(3) Complete inner array pier design, construction drawings, and submit for bids.

Nathaniel M. White
Project Manager

13 April 1993

QUARTERLY PROGRESS REPORT
JULY–DECEMBER 1992

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: This report covers the fourth and fifth quarters of the NRL–Lowell site develoment contract. Significant progress occurred, despite starting late in the construction season. During the period, all NEPA/USFS requirements were met, a Decision Notice and Permit to Proceed were signed, the basic underground infrastructure was installed, the paved access road to the building sites was completed, the control buiding was nearly completed, three-phase power was been brought to the top of the mesa, and the design and construction drawings of the lab building were nearly completed.

ACCOMPLISHMENTS

(1) The NEPA/USFS process drew to a close upon issuing the permission to proceed date of 24 August 1992. The final environmental assessment report dated 31 July 1992 contains the concerns and conditions for construction. The process included six months of intense study of cultural and environmental impacts, compilation of four separate reports based on field surveys and analysis, public input, and discussions and agreements on mitigation measures.

Reports accepted and on file with the Coconino National Forest:

(a) Cultural Resources Inventory for the Proposed Location of Phase I Construction of the Navy Prototype Interferometer, within the Lowell Observatory Astronomical Special-Use Permit Area on Anderson Mesa, Coconino National Forest, Arizona; May 26, 1992

(b) Scoping Document: Lowell Observatory Long-Term Management Plan for the Opperation of the Astronomical Facilities on Anderson Mesa Coconino County, Arizona; June 11, 1992

(c) A Summary of Cultural Resources Project within the Proposed Lowell Observatory Astronomical Special-Use Permit Area Boundaries; June 23, 1992

ACCOMPLISHMENTS (CONTINUED)

(d) Final Environmental Assessment: Lowell Observatory Long-Term Management Plan for the Operation of Astronomical Facilities on Anderson Mesa, Coconino County, Arizona; July 31, 1992

(2) The basic underground infrastructure was completed. All power and communication conduits between the existing compound, the control building, and the lab building site are in place. Arizona Public Service underground power conduits were installed to APS specifications. A 10,000-gallon cistern with collection and distribution system is finished. The propane storage and piping is completed.

(3) The site access road was completed by October 19. Soils test results, efficient access, natural drainage pattern, maintenance, and environmental concerns were addressed in the road design. The array access road, an extension to the site access road, will be constructed during the summer of 1993.

(4) The control building is near completion. Final design in consultaion with NRL and USNO personnel was completed in late September with bids being received in October. Construction began the first week of November. The building is enclosed and weather tight.

(5) Three-phase power has been brought to the top of the mesa but not to the control building.

(6) The design of the lab building is nearly complete with the penultimate drawings thoroughly reviewed by NRL, USNO, and Lowell personnel. Geotechnical data from site core drilling were part of the basic engineering data.

PROBLEMS OR DELAYS

(1) The NEPA/USFS requirements set the starting date for final design and construction. Site plans and designs were subject to revisions until the Decision Notice signing and public input period ended August 24.

PROBLEMS OR DELAYS (CONTINUED)

(2) Delays in the contract cash flow postponed the control building start date about three weeks. The lab building design time was lengthened significantly and the hoped for construction start date slipped effectively two months for the same reason. This problem has been resolved.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Complete control building for occupancy.

(2) Begin construction of the lab building (winter construction is weather dependent).

(3) Proceed on the design and construction drawing for the array piers, pipes, and access roads.

(4) Complete power installation to the site.

Nathaniel M. White
Project Manager

31 December 1992

QUARTERLY PROGRESS REPORT
APRIL–JUNE 1992

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: During the third quarter of the NRL-Lowell site development contract, extraordinary efforts were made to meet NEPA/USFS requirements, test holes were drilled and temperature monitoring completed, further design refinements on the site plan were completed, and continued discussions and refinements of the general requirements of the array and lab buiding.

ACCOMPLISHMENTS

(1) The NEPA/USFS have absorbed much of the project's time and costs this quarter. SWCA, Environmental Consultants were hired to expedite the process at the advice of the USFS. A decision notice to begin has still not been given by the USFS. A short list of the tasks and reports we have performed and produced follows.

(a) A public hearing was held at the Observatory and a prescoping document was prepared and reviewed by all parties.

(b) Research on archeological studies, wildlife and plants (work completed earlier in a Lowell-commissioned study), visual impacts, and trail impacts was completed resulting in several reports.

(c) Several drafts and reviews of the Scoping Document were produced in consultation with many USFS personnel resulting in a final document.

(d) The Environmental Assessment (EA) document has been finalized by our consultant after several revisions, although it has not been approved by the USFS at this time.

(e) Further archeological surveying was required and completed for the EA, resulting in two more reports.

(f) Two additional reports concerning the impact of blasting and the stability of the bottom of Prime Lake were produced through small contracts.

(g) Many meetings, phone calls, and on-site visits occurred to facilitate the process.

ACCOMPLISHMENTS (continued)

(2) A 25-ft and a 55-ft test hole were drilled to determine bedrock conditions and to monitor subsurface temperature stability. This project was completed. Temperature profiles for a week per hole and on a 39-ft tower were obtained at 30-minute intervals. The data were sent to Dr. Hutter.

(3) Some site plan design changes were made to accommodate USFS concerns. The actual road, array and building outlines were staked on site. This established the exact locations of impact within the permit area.

(4) Continued development of design requirements and the associated design and engineering personnel needs to implement the construction were discussed and researched in preparation for an immediate start when permission is given.

PROBLEMS OR DELAYS

(1) Meeting NEPA and USFS requirements has continued to be a challenge and is the only reason for the slipping start date.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Obtain USFS approval for site construction.

(2) Design and build access roads.

(3) Bring power and telephone to the site.

(4) Build control building.

(5) Design lab building and hopefully construct outer shell.

Nathaniel M. White
Project Manager

14 July 1992

QUARTERLY PROGRESS REPORT
JANUARY–MARCH 1992

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: During the second quarter of the NRL–Lowell site development contract, site surveying was completed, a site plan was developed and finalized, building designs were considered and selected, numerous discussions with the U. S. Forest Service (USFS) were held for the purpose of meeting NEPA requirements, and cost and scheduling discussions continued with contractors, Arizona Public Service, and US West.

ACCOMPLISHMENTS

(1) The aerial site survey was field checked and found to meet site-plan accuracy requirements (0.2 feet). The survey grid was tied to a true north–south line by solar and stellar measurements to better than 10 seconds of arc.

(2) After four iterations, a final site plan was agreed upon. Scientific needs were not compromised while mitigating environmental impacts and reducing construction costs. NRL, USNO, Lowell, Loven Contracting, and WFM civil engineers provided input into the decision process.

(3) The control building design was developed and completed. The optical laboratory design has been developed to the point where final design of the internal optical layout is necessary for design completion.

(4) A major effort to finalize and meet NEPA and USFS requirements for their approval of the project began immediately following the completion of the site plan in March. This was preceded by an 18-month series of meetings with the USFS on this topic, including contracting for an environmental assessment. After several attempts to carry the process forward with our staff, it was decided to contract with a firm that specializes in this process.

(5) The requirements and capacity for installing power and telephone to the site have been specified.

ACCOMPLISHMENTS (continued)

(6) A construction management team has been formed.

PROBLEMS OR DELAYS

(1) Meeting NEPA and USFS requirements is somewhat poorly defined because of the many individuals that must separately but equally pass judgment. We are attempting to fully and efficiently meet all requirements; however, construction cannot begin until we have USFS approval.

(2) Due to weather and scheduling conflicts, the thermal test holes were not drilled in March as planned.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) Obtain USFS approval for site construction.

(2) Drill and monitor test holes.

(3) Design and build access roads.

(4) Construction staking of the phase I site.

(5) Power and telephone will be brought to the site.

(6) Submit RFP for control building construction.

Nathaniel M. White
Project Manager
Nat White
28 April 1992

QUARTERLY PROGRESS REPORT
OCTOBER–DECEMBER 1991

CONTRACT N00014-91-C-2224
CONTRACTOR: LOWELL OBSERVATORY

SUMMARY: During the first quarter of the NRL–Lowell site development contract, an aerial photogrammetric survey of the site was completed. Preliminary estimates of unit and total site development costs were provided by a local contractor based on general design needs and assumptions.

ACCOMPLISHMENTS

(1) The Naval Research Laboratory–Lowell contract became effective on 16 September 1991. The goals of this contract, N00014-91-C-2224, are described in the Lowell proposal to NRL entitled "Support of the Prototype Optical Interferometer."

(2) Site survey technical specifications were developed for an RFP sent to nine engineering firms. WFM Engineers and Surveyors of Flagstaff was selected. In a race against winter weather, contracts were let and stereoscopic aerial photographs were taken of the site. The 2-foot contours and 1-foot contour subarea maps have been delivered in print and digitial form as specified.

(3) A detailed preliminary estimate of development costs for the facilitity described in OIPTR 91-014 was researched and compiled by a local building contractor. The cost estimates were based on local construction costs for comparable structures. The estimate within about 10% is $1.8 million, not including design costs. Subsequently, the facility and site plans have changed.

PROBLEMS OR DELAYS

(1) Although snow and bad weather could have delayed the aerial survey for an entire season, luck and hussle enabled completion of the project on schedule.

PLANNED ACTIVITIES FOR NEXT QUARTER

(1) A preliminary site plan will be developed.

(2) Bid specifications will be developed for the bidding process, which could begin in February or March. A spring construction start is anticipated if this schedule is met.

(3) A construction management structure will be formed.

(4) Test holes will be drilled for underground thermal stability measurements.

(5) The U. S. Forest Service Site Management Plan and permit process will be pursued.

Nathaniel M. White
Project Manager

9 January 1992